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# LynxNet:

## Wild Animal Monitoring Using Sensor Networks



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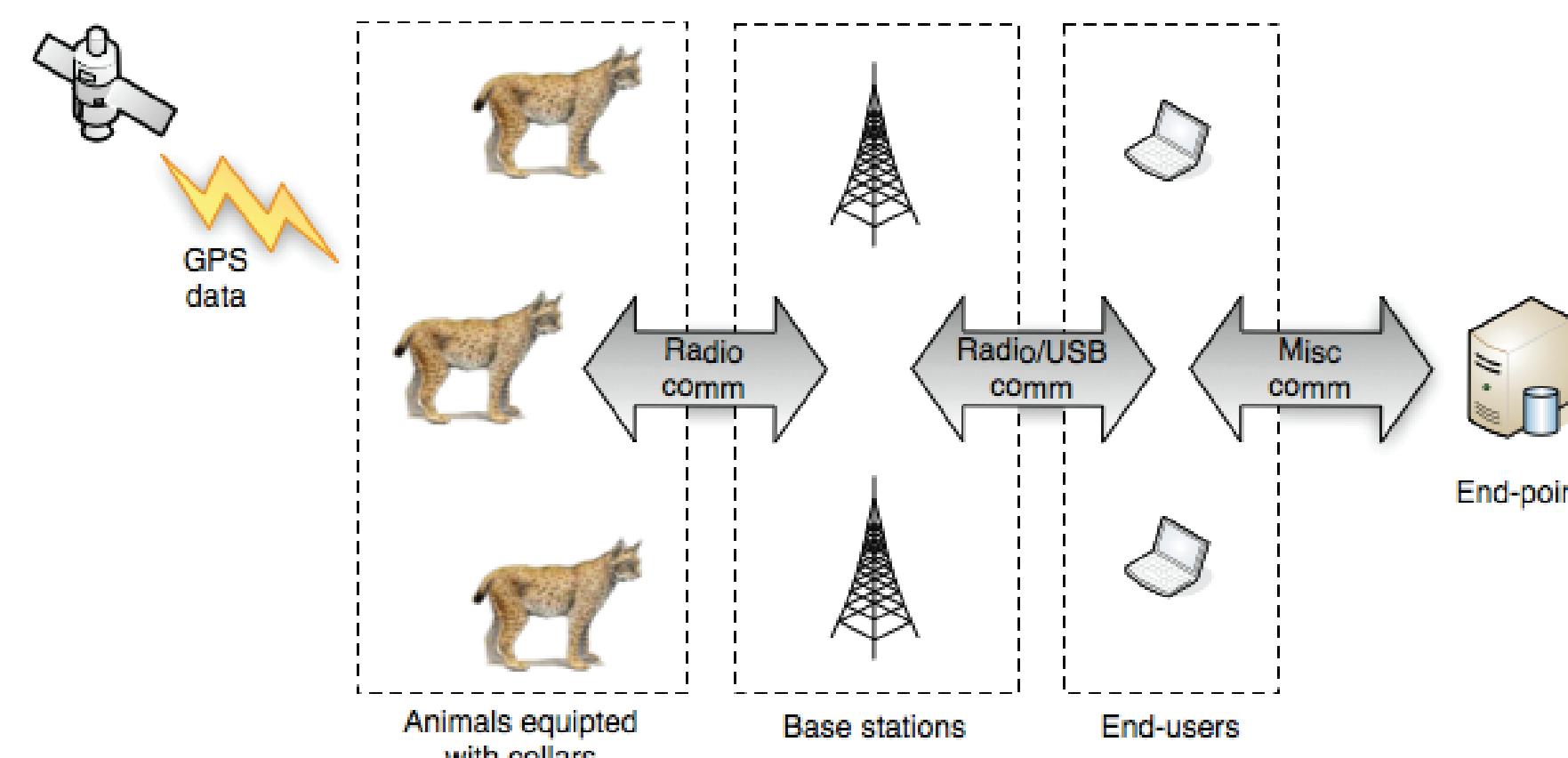
Latvian State Forest Research Institute "Silva"  
http://www.silva.lv/

**Vision:** Improved and robust animal monitoring wireless sensor system usable for any type of wild animal monitoring

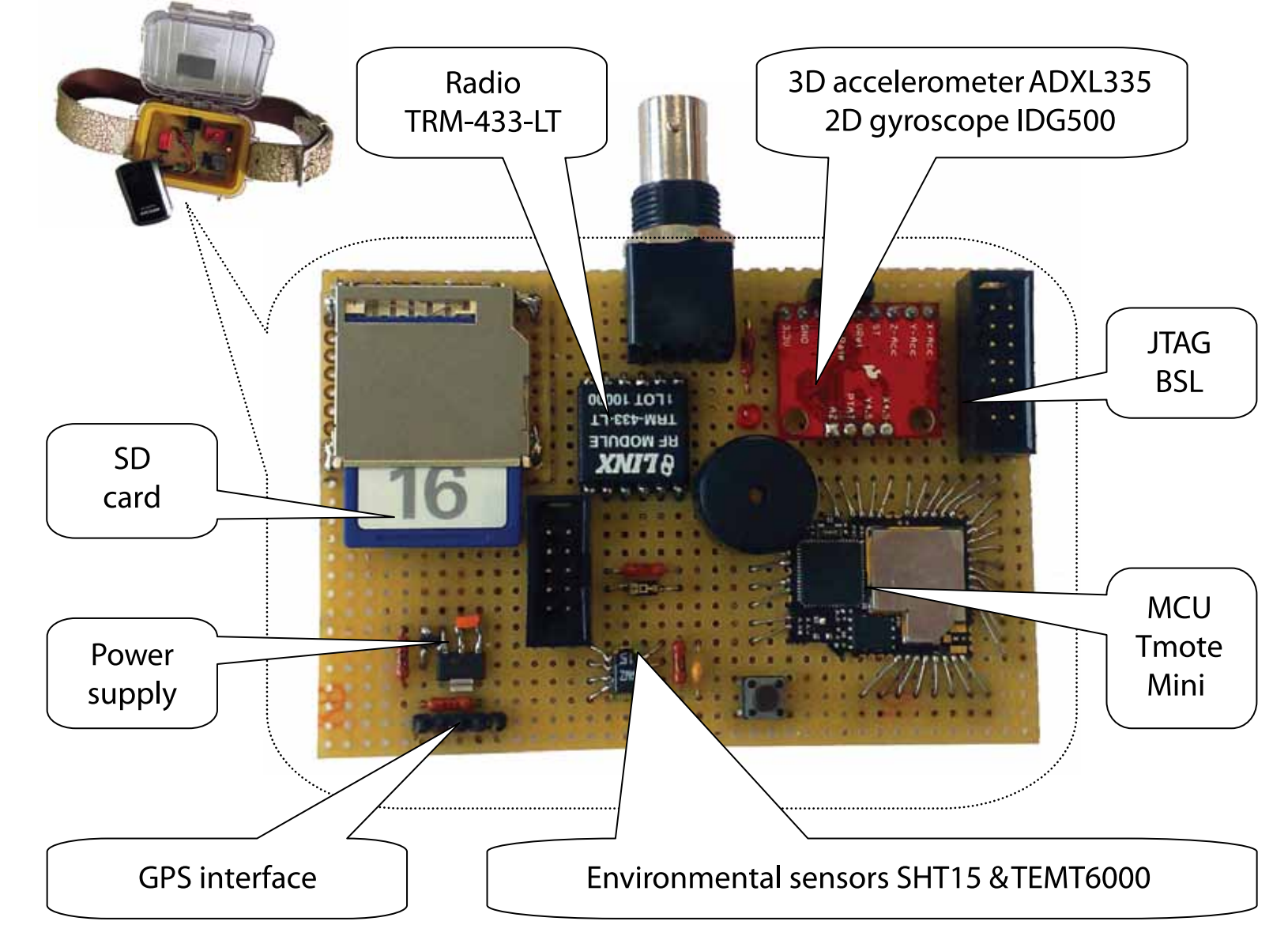
**Approach:** Creation of animal monitoring architecture with extended sensing modality and multi hop delay tolerant communication approach

**Challenge:** Achieving long-term operation using single set of batteries in forest environment with no energy harvesting capabilities

### LynxNet System Architecture



### Collar Device Prototype



### Software

- Based on MansOS WSN operating system [1]
- Data acquisition: periodic sensor and GPS reading
- Data acquisition: activity detection (work in progress)
- Data storage: periodical logging to SD card
- Data collection: radio communication with proximate base stations

### Structure of Packets

Field	Size (in bytes)
Timestamp	4
Node ID	1
Latitude	4
Longitude	4
GPS Info	1
Temperature	2
Humidity	2
Light	2
Total size	20

GPS packet

Field	Size (in bytes)
Timestamp	4
Node ID	1
Accel X Axis	2
Accel Y Axis	2
Accel Z Axis	2
Gyro X	2
Gyro Y	2
Total size	15

Activity packet

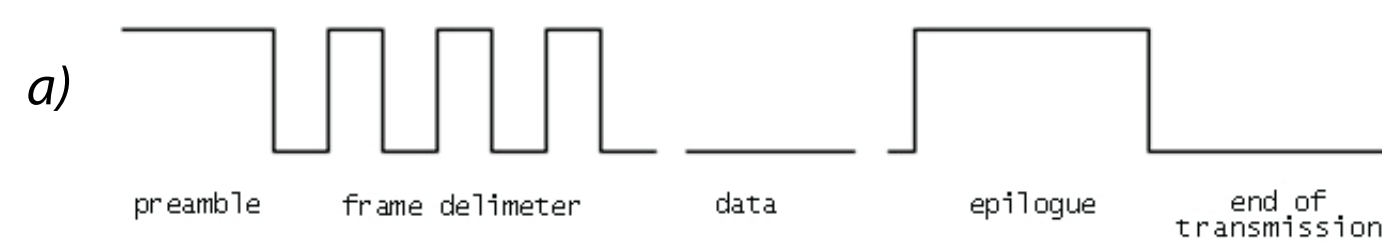
### Collar Device Energy Consumption

Mode	Active		mW daily
	seconds per hour	mW	
Sleep	3527.123	0.033	0.78
GPS	60.0	218.79	87.52
Sensors	12.0	37.62	3.01
Radio RX	0.246	31.68	0.05
Radio TX	0.631	52.14	0.22
<b>Total:</b>			<b>91.57</b>

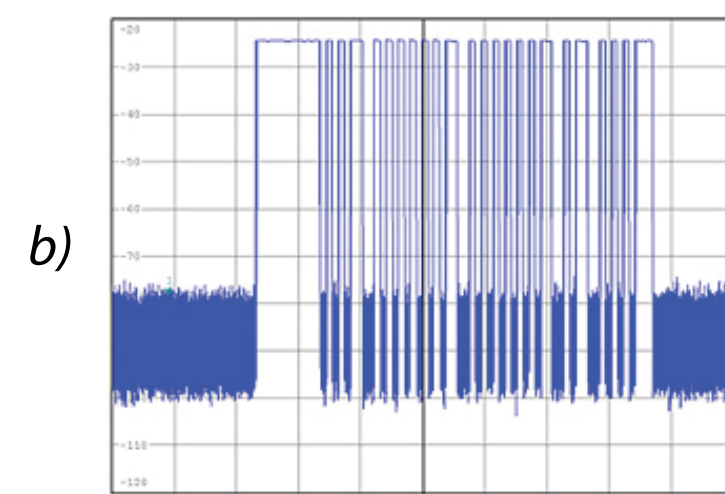
Using Enix Energies battery of 6800mAh 3.75V the lifetime would be up to 15 months. GPS constitutes 96% of total energy consumption.

### Radio Communications

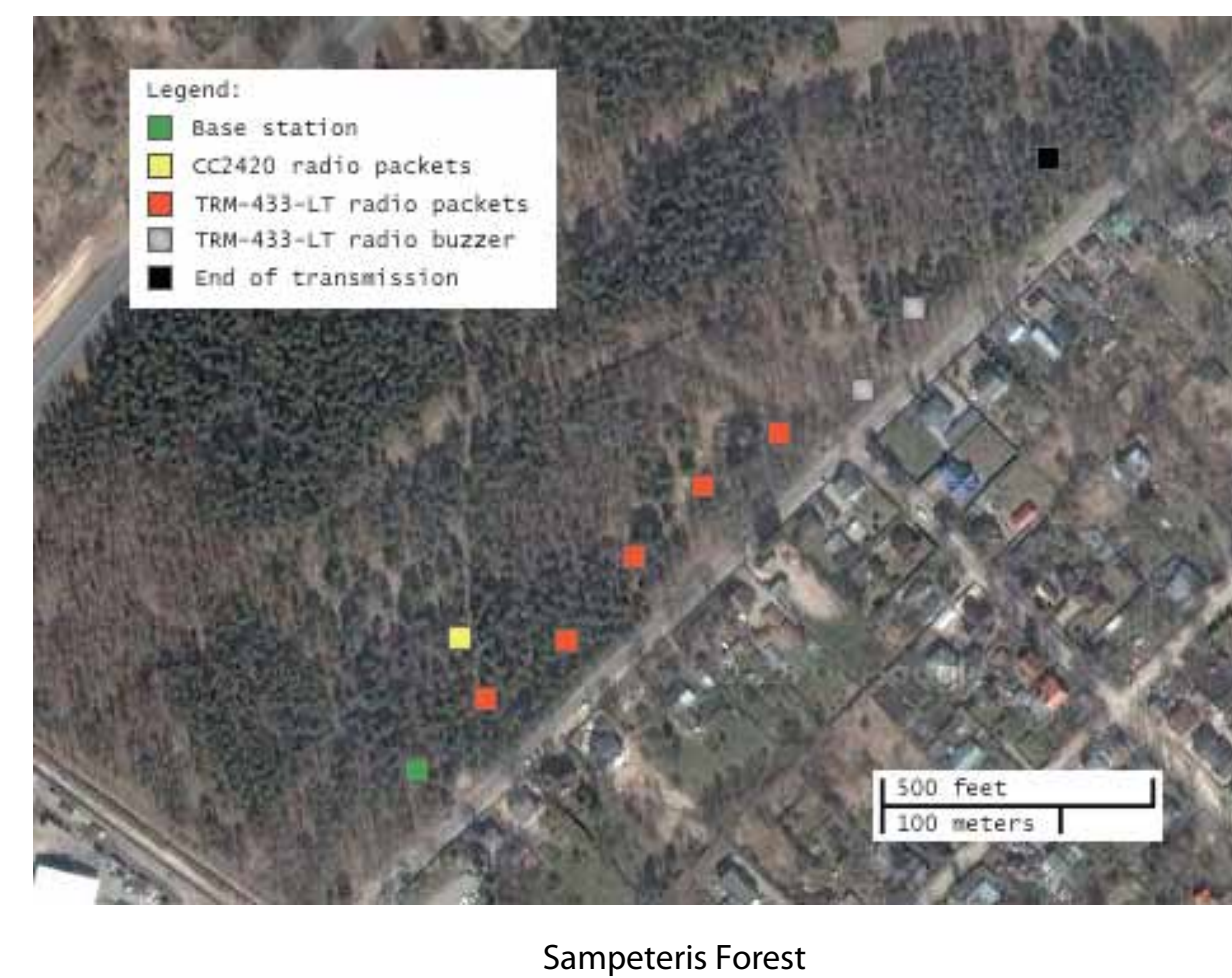
- LINX TRM-433 long range transceiver
- 10 dBm output power, -112 dB receive sensitivity, 10 kbps maximum data rate, OOK modulation
- We designed custom PHY and MAC layers
- Tmote Mini built-in CC2420 transceiver can be used as a complementary solution



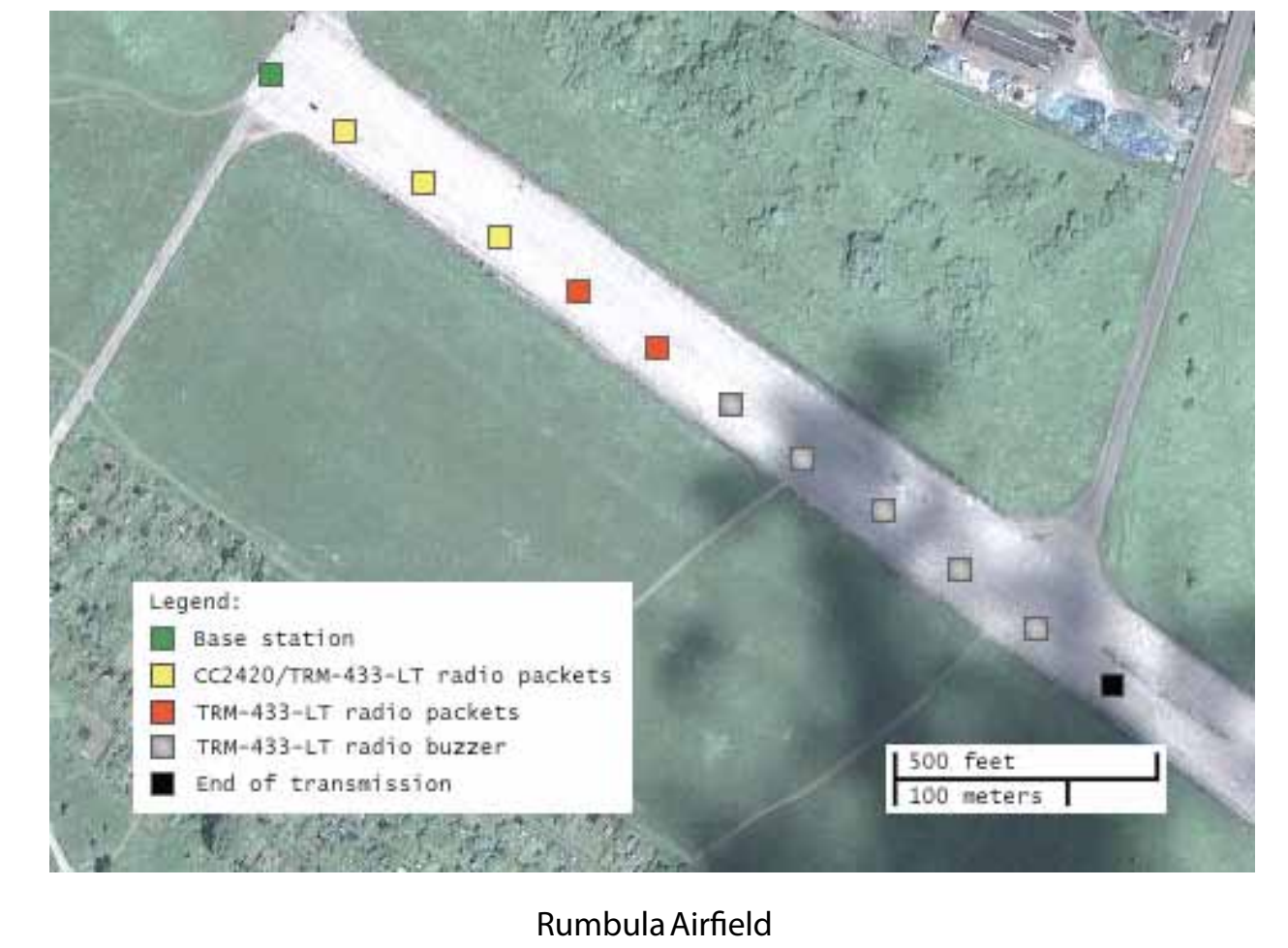
PHY layer data frame format: (a) in theory (b) in spectrum analyzer



### Field tests



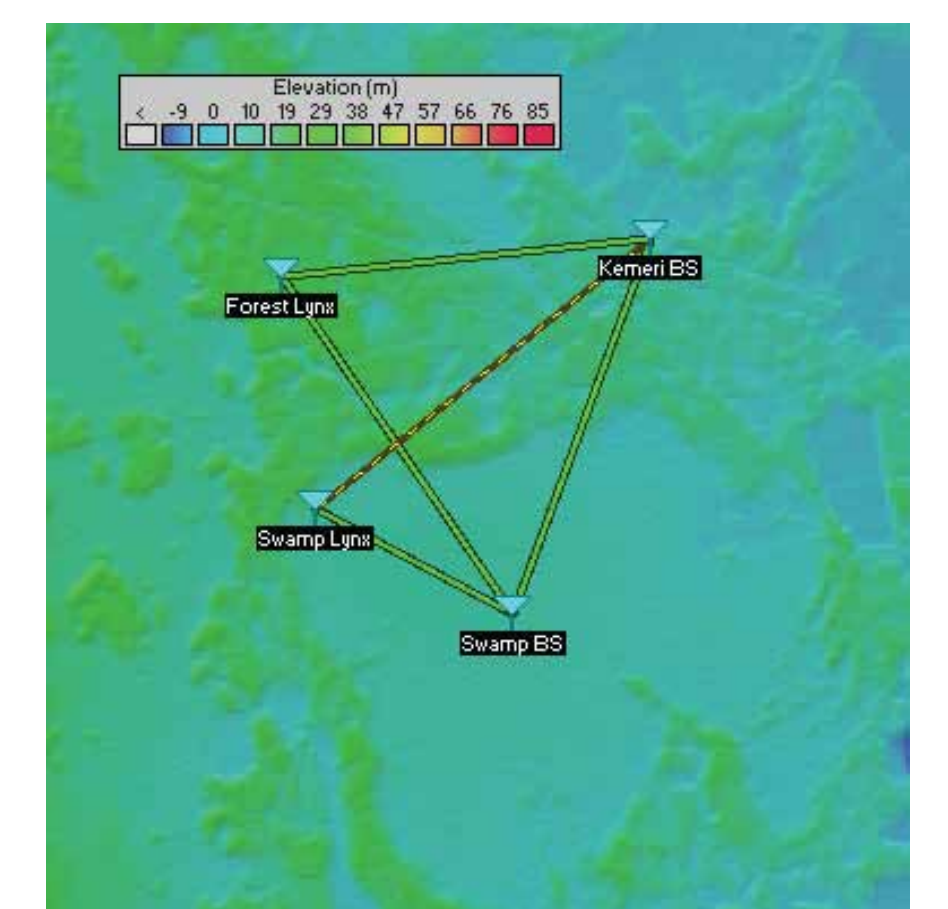
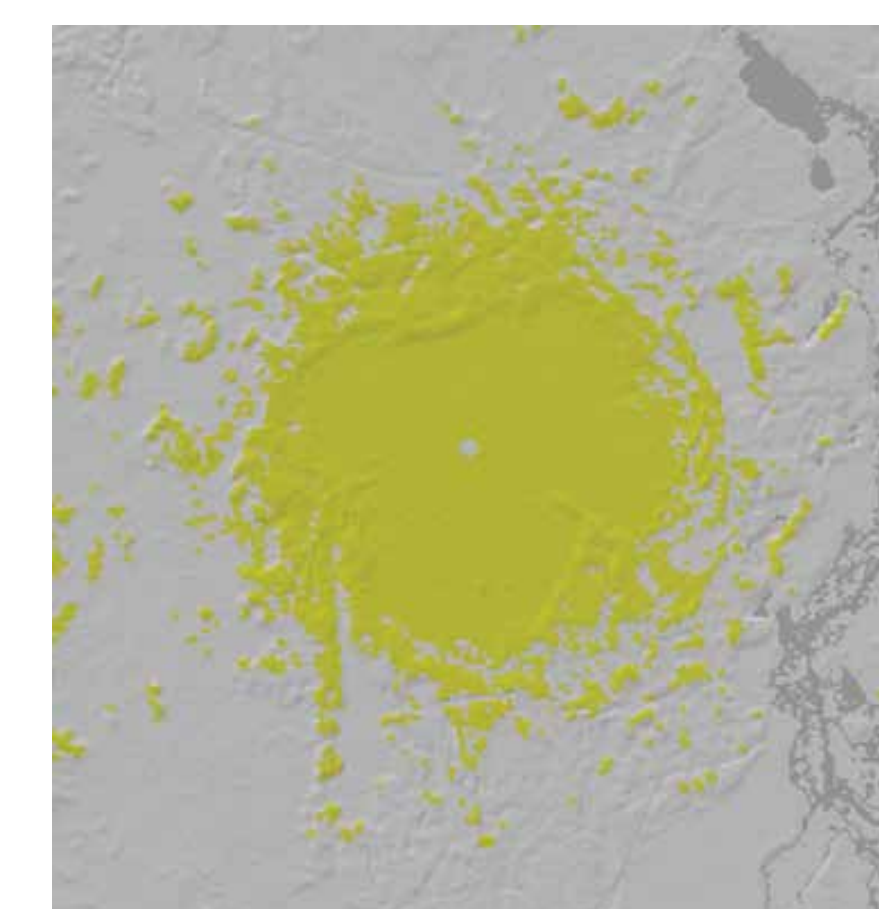
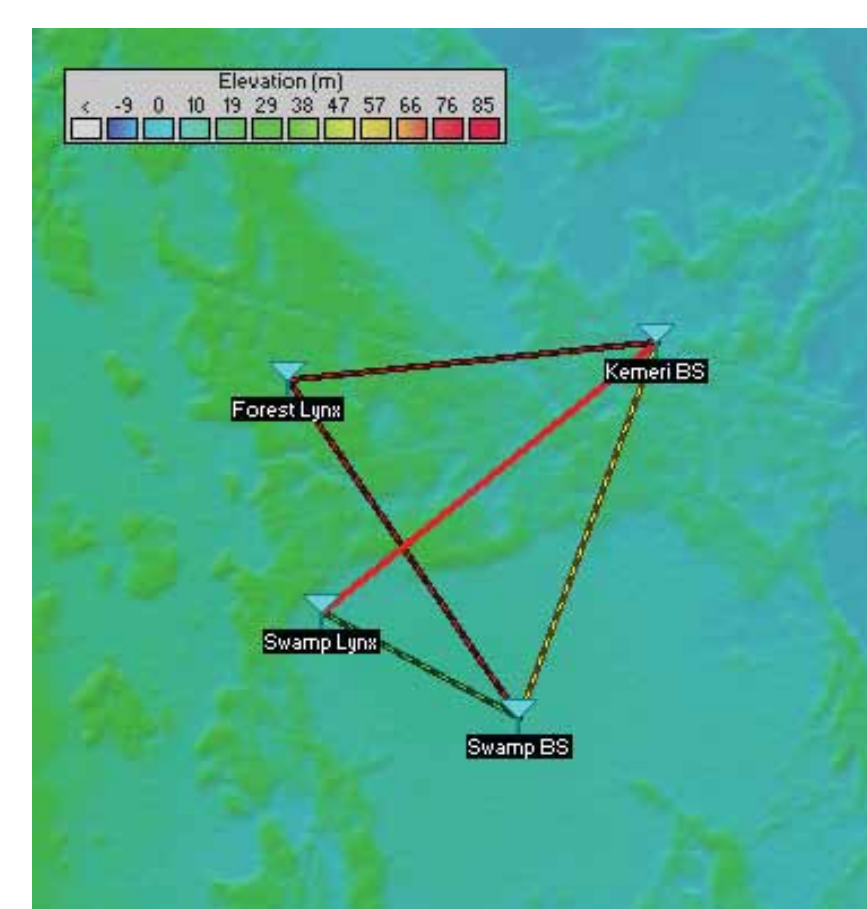
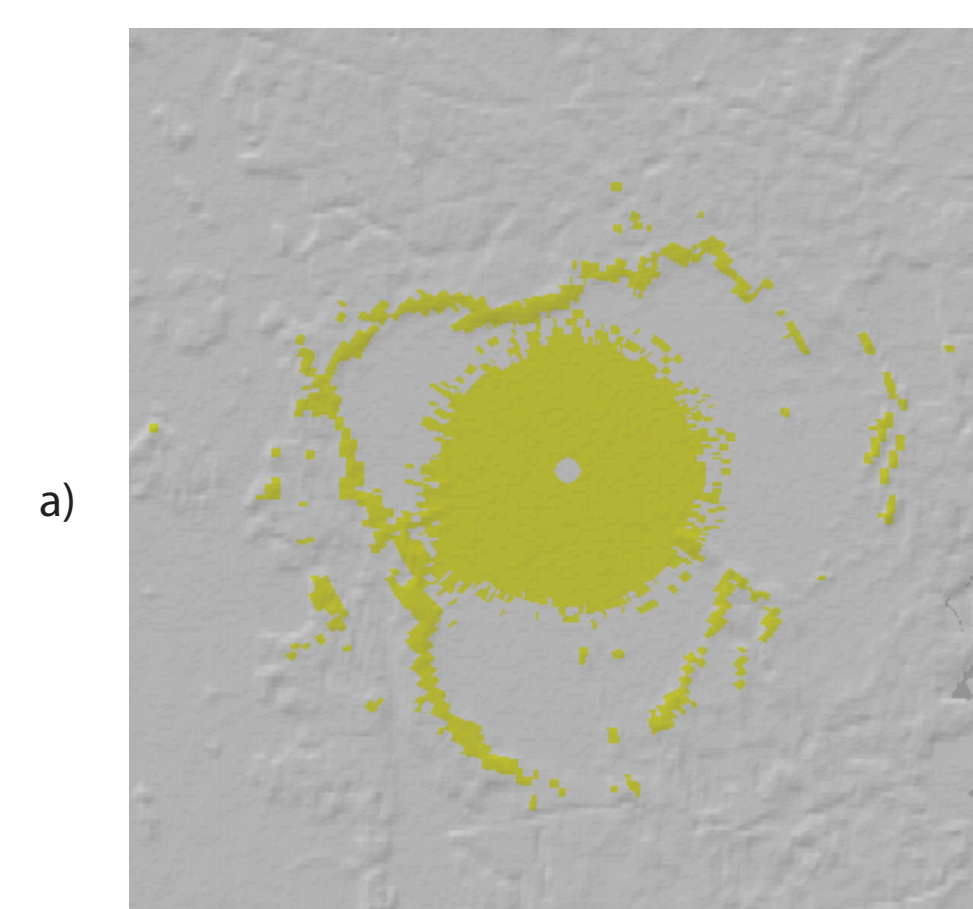
Distance (meters)	Percentage of packets received		RSSI (max value 4095)	
	Airfield	Forest	Airfield	Forest
50	80-100%	80-100%	2700	2800-3000
100	80%	80-100%	2200	2200-2500
150	80%	70-90%	1900-2000	2300
200	40-80%	10-50%	1600-1800	1600-1800
250	10-80%	20-50%	1600-1800	1600-1800



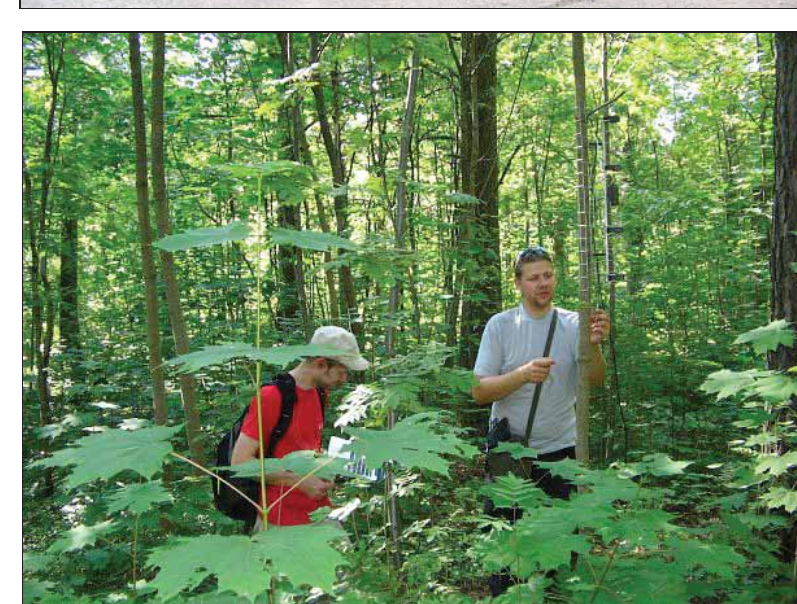
With CC2420 chip we achieved 150 meters radio range on airfield and 65 meters radio range in forest, while TRM433 radio transmitted packets successfully up to 250 meters. In addition we measured analogous signal transmission, which was successful up to 500 meters, suggesting that our PHY layer implementation has potential for improvement.

### Evaluation of Radio Coverage in Potential Place of Deployment

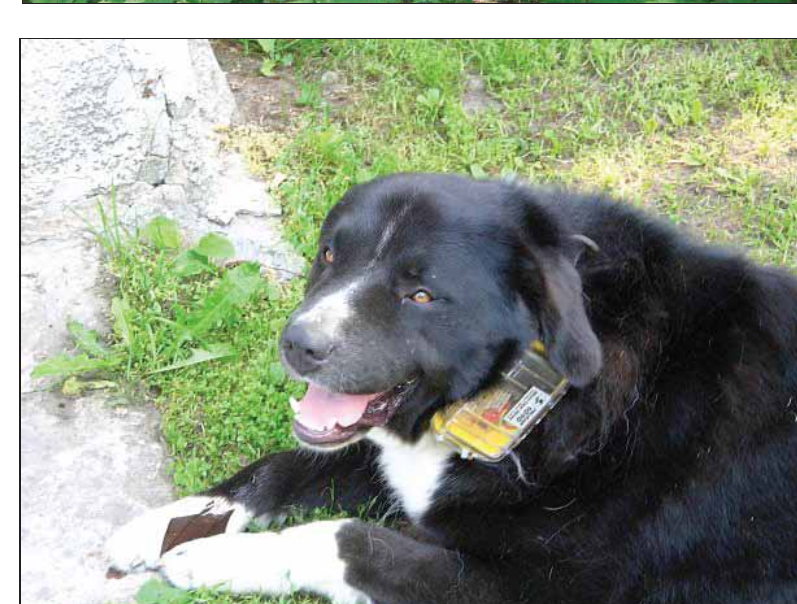
- Radio bands evaluated - (a) 433MHz and (b) 152MHz
- Place of deployment - Kemeri National Park
- Parameters used for radio simulation:
  - 20dB TX power
  - 4dBi antennas on both sides
  - 6m height for base station
  - 0.5m height for lynx
  - 2dB cable loss on both sides
  - 110dB RX sensitivity



Field test setup on Rumbula airfield



Field test setup in Sampeteris forest



Our self-styled lynx Spike



Eurasian Lynx  
(Lynx Lynx)

### Future Work

- Further evaluation of collar device after longer deployments
- More stable radio communications
- Activity monitoring
- Selection of optimal components
- System redesign for usage in 152MHz band
- Robust packaging design

Additional References:

1 - G.Strazdins, A.Elsts, and L.Selavo, "MansOS: Easy toUse, Portable and Resource Efficient Operating System for Networked Embedded Devices", SenSys '10 Proceedings of the 8th ACM Conference on Embedded Networked Sensor Systems